

# Blockchain Integration in Artificial Intelligence: Benefits, Applications and Research Challenges

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## Abstract

Nowadays block chain and artificial intelligence are the two emerging technologies. Both strategies bring change to the market, but the level of creativity and complexity varies. Block chain is a decentralized and distributed ledger technology which is used for storing information in multiple locations without any centralized monitoring system. Artificial intelligence imitates the problem-solving capability of human mind and decision making abilities by using computers, data, and sometimes machines. When both technologies are merged, their formed new opportunities and possibilities from the advantages of both, like productivity gain and the security and transparency. The convergence of AI with blockchain technology can bring a wide change in businesses by securing data, transparent data, and making it overall efficient. One of the most useful concepts of the two technologies is in cyber security. The technologies, which combine the capabilities of AI with the block chain's dependable, scattered nature, may be utilized to enable management of recourses and decision making in areas such as education, impact on society, healthcare, agricultural production, urban planning, and others. Artificial intelligence (AI) is capable of helping detect and react to risks, whereas the integrity and security of information may be ensured using blockchain technology. A comprehensive survey of various applications of blockchain for AI has been completed. Evaluated various literature based on the technologies, and the new blockchain-based applications, mediums, and technological advances that target the AI sector were collected and summarized. In addition, Open research issues concerning the use of blockchain technology for AI are addressed.

**Index terms:** Blockchain, Artificial Intelligence, cyber security, smart grid, Consensus

## Introduction

Today's most novel innovation technologies are Blockchain and Artificial Intelligence. When linked, they open up new possibilities, allowing an entirely new set of apps to benefit from the advantages of both, like productivity gain and the security and transparency. The merged blockchain and AI can create machine learning algorithms that are intelligent for making decisions that generate extremely trustworthy outputs causing exact real-world actions based on immutable, impermeable data. In total, 90 unique papers on this topic were considered for this review. The advantages in integrating of AI in blockchains are growing in popularity.

AI and blockchain combo supports almost all company where they are used. The Dartmouth Society developed the notion of artificial intelligence technology in 1956. As a significant field of computer science, artificial intelligence technology is a new innovative technology which mimics, expand, and improve intellectual capacities. A blockchain network provides a commercial settlement layer that is visible, peer-to-peer, and free of restrictions, allowing for immutable data storage and permission-less, trustless digital transactions. Cyber security is another field which has impact on integration of AI with block chain. AI and blockchain will act as a twofold defense against cyber threats.

Blockchain technology as decentralized databases gives access to users on database of records, data transactions, and information through a decentralized, secure, and transparent system. Smart contracts on blockchain technology may not require a central authority to govern interactions with users. AI, enhances the ability of boosting to reasoning and making decisions. However, merging these two technologies could result in a significant shift in the market. Both technologies are cutting-edge, but by integrating them, tasks might be accomplished faster and with less effort. This realization prompted an inquiry into a systematic evaluation of blockchain and AI combo papers published between 2012 and 2022.

A comprehensive survey of integrating blockchain applications in AI has been completed. The literature was studied, and the blockchain apps, systems, and mechanisms under development explicitly directed at the AI domain were tabulated and summarized. In addition, open research concerns related to the application of blockchain technologies for AI are addressed.

Blockchains could benefit from AI as well. For example, AI could boost the intelligence of blockchain-based business networks and provide them a competitive advantage since it can read, analyze, and find links between data fast and completely.

AI models incorporated in blockchain-enabled smart contracts might employ predefined thresholds and events to conduct transactions like reorders, payments, or inventory purchases, as well as urge expired products to be recalled. Furthermore, AI systems may be useful in detecting fraudulent behavior on the blockchain. As a result, AI and blockchain can collaborate to expand and automate transaction evaluation steps.

With AI-driven smart contracts, the combined technologies has the potential to create entirely new business models, strengthen organizational structure operational efficiencies, assist individuals in automating repetitive tasks, enable more secure and improved decision-making processes, and increase overall confidence and Transparency in key structure and systems of commerce is essential. The Integration of AI with blockchain has the potential to provide various benefits rather than business applications.

This technology could be applied to areas such as health care, educational institutions, energy, social effects, the farming industry, urban development, and others by combining AI's powerful ability to analyze with the secure, decentralized nature of blockchains to enable decision-making based on data and more efficient management of resources.

AI can mine a vast dataset successfully to develop novel challenges and find data-driven trends. Blockchain technology can help to effectively remove defected data sets. Decentralized blockchain infrastructure is used to confirm the authenticity. This is true for every customer-facing business, including retail transactions. AI in market place is build by collected information from clients. Advantages in analyzing, predicting, judging, and taking decisions, artificial intelligence are used in industries to strengthen security, banking, retail, transit, and education. Blockchain technology emerged very late, with Satoshi Nakamoto's Bit coin proposal in 2008.

Artificial intelligence and blockchain together offer many advantages, yet they have drawbacks. Blockchain has concerns about consumption of energy, adaptability, safety, confidentiality, and effectiveness, whereas AI has problems about accessibility and performance. They can be connected and benefited from natural integration as two independent study paths.

Public blockchains present various privacy and control challenges for business use in a range of industries. Here all employees are given complete access to the contents of databases. As an outcome, a new type of private blockchain is emerging, in which control is kept by a single union, and no one can access the network without a legitimate identity. Private block chains mimic centralized networks, but they give all benefits of the distributed systems while keeping overall control to improve privacy.

As a result, an innovative kind of private blockchain is emerging in which control is ultimately kept by only one organization and no one may access the network unless they have a verified identification. Private block chains are similar to centralized networks, but they provide all of the distributed benefits while maintaining overall control, improving privacy, and avoiding many of the criminal behaviors associated with public blockchains and crypto currencies. Humans or traditional computing cannot match AI's potential to boost blockchain efficiency.

## **2. Blockchain**

Blockchain-related application possibilities are based on four major blockchain technologies such as cryptography, consensus mechanism, data structure and scattered storage. It may be defined as a secure on a peer- shared ledger used for transaction recording. It provides a platform for consumers to conduct transactions without relying on a trusted arbiter.

### **2.1 Consensus Mechanism**

The blockchain has built a significant consensus system that ensures each nodes in network are will take the lead to monitor their accounts. The following are examples of common consensus mechanisms:

1. The basic consensus technique is the proof of work (PoW), and all nodes that are participating compete for keeping records by comparing computer power. Time and many resources get wasted if everyone contributes and a single node is only selected.
2. In the case of the proof-of-stake (PoS) mechanism, the more resources have and the longer keep the digital currency, and this technique is obtained through the right to accounting and incentives, which saves time.

3. The delegated proof-of-stake (DPoS) technique picks suitable blocks for client verification and keeping records, which is more straightforward and successful, in the expense of some decentralization.

## 2.2 Data Organization

The blockchain is made up of blocks that link together to form a entire chain. Every block is having previous hash refers to hash value of previous block. Hash pointers connect one block to previous block forming a chain. Blocks are linked cryptographically using hash values. Any change in data stored in block result in breaking the chain.

## 2.3 Cryptography

Cryptography is a game-changing element of blockchain. The usage of symmetrical data encryption is akin to opening and closing a door with the same key. Asymmetric encryption is analogous to utilizing two different keys to unlock and close namely the public key and the private key. The private key must be safe, if it is lost means assets are lost. The blockchain is relatively safe because the public key and private key are generated through several transformations.

## 2.4 Distributed Storage

The most appealing aspect of blockchain is its distributed storage method. To prevent malevolent nodes from causing harm, new block with data in the blockchain uses the PoW consensus process must be unanimously acknowledged and agreed upon by the majority of nodes, with at least 51% of the nodes agreeing. As a result, tampering with data is tough.

## 2.5 Cross chain Technology

Cross-chain technology is a fundamental technological solution for achieving connectivity and scalability in blockchain. Blockchain network morphology differs from that of the Internet.

## 3. Artificial Intelligence

Artificial intelligence refers to the emulation of human intellectual processes by technology, specifically computer systems. Examples of AI applications include expert systems, natural language processing, speech recognition, and machine vision. In general, AI systems operate by amassing enormous amounts of labeled training data, analyzing it for trends and associations, and then employing these patterns to anticipate future states.

Artificial intelligence programming focuses on cognitive abilities like the ones listed below:

- Learning: This feature of AI technology is concerned with data collection and the development of rules for transforming it into meaningful knowledge.
- Reasoning: This aspect is related with picking the finest algorithm to achieve a result.
- Self-correction: This feature is designed to continuously evaluate algorithms in order to get most accurate results possible.
- Creativity: This field of artificial intelligence utilizes AI technologies like neural networks, rules-based systems, statistical techniques, and other to produce new visuals, writing, music, and ideas.

## 4. The combined benefits of blockchain and AI

### 4.1 Authenticity

Digital records of blockchain are visible to the AI framework. This boosts confidence in Integrity of data and by extension, AI suggestions. Blockchain storage and distribution of AI models provides data security.

### 4.2 Augmentation

Blockchain-based business networks a new level of intelligence, gives access to a large amount of information from both inside and outside the organization, enables to provide more relevant insights and develop a Accurate and truthful data market.

### 4.3 Automation

Blockchain along with automation AI give new value to other organizations by reducing accelerating and improving efficiency. It can recall and carry out predefined criteria and events, and select the most suitable route.

## 5. How Blockchain Can Help AI

AI models can build in using combination of block chain and AI.

- Data sources must be transparent and reliable: smart blockchain technology, among other things, maintains data transparency on the chain by coordinating the overall database of the nodes and enabling data tracking via action Signed documents and time stamps.
- The Strong Fairness Guarantee: Smart block chain technology assures that system members earn corresponding incentives if they honestly fulfill the contract via smart contract codes.
- Effective Autonomy: The uncertainty and potential assaults are reduced by predefined rules by management in smart contracts with the human role process.
- Privacy Protection: It is to create an erasable blockchain system that can hold user's data responsible while retaining privacy.
- Distributed computing Ledger: With its distributed nature, Blockchain enables the decentralization of computing capacity, which is helpful for running artificial intelligence and realize decentralized computing.
- Several participants have built a clear information-sharing route. A multi-user workflow manages interface and creates a record for every process of managing the AI model, including:
  - Using blockchain as a certificate authority, all users are visible.
  - A lasting record of the initial aim of the AI model.
  - Keep track of the AI model's ongoing governance, evaluations, and ratings.
  - Giving trained data as well as algorithms to all AI components, a single source of truth.
  - Providing client trust logos so that blockchain history may be easily evaluated.
  - Creating a stable experiment record among AI engineers and MLOps
  - To act as a portable permanent artificial intelligence storage bank.

## 6. Technical Enhancements that AI can enable

- **Security:** Blockchain technology becomes safer by integrating AI to assuring the security of future application deployments. AI systems, for example, are increasingly assessing if trades in money are against the law and should be debarred or investigated.

- **Efficiency:** AI is useful in the simplification of algorithms and more rapid interactions. If AI gadgets replaced miners' labor, the cost charged to miners and the energy expended would be lowered.
- **Trust:** One of block chain's distinguishing features is its database records. When combined with AI, people can track and watch the system's thought process. This increases trust, and allowing them to share large scale data.
- **Improved Management:** Human experts get stronger at cracking codes with practice. AI mining approach can eliminate the requirement for human expertise. As a result, AI helps to improve the administration of blockchain networks.
- **Privacy and New Markets:** The privacy of blockchain can be strengthened by using "Homomorphic encryption" techniques. Homomorphic algorithms are those that allow operations to be conducted directly on encrypted data.
- **Storage:** Blockchains are one of the best technology to store high sensitive, personal data, which may provide value and convenience when managed properly with AI. An excellent example is innovative health care systems that use labs and scan reports records to deliver accurate diagnoses.

## 7. AI Blockchain Application

Based on level of decentralization and access, blockchain technologies are classified as

1. Permission (i.e., only authorized users can use the blockchain)
2. Permission less (i.e., available to all Internet users) systems.

### 7.1 Public blockchains

In public blockchains anyone can access and open. Because of their openness, these blockchains manage user to read or write data in the blockchain. Furthermore, for security and consensus procedures, these public blockchains employ complicated protocols. When a new block is created, it publishes on the network with no conditions. A token is associated with them which is designed to incentive and reward the participants. Data security may occur as this type of blockchains is always subject to malicious security breaches.

### 7.2 Private block chains

A single organization manages a private blockchain. Private block chains are permission systems in which users and participants need consent to join the network transactions. They are centralized compared to public blockchains. As network participants are known, this type of blockchains are significantly faster; thus, validating transactions on the network involves less complex mathematical calculations. Furthermore, Private block chains are capable of transporting any form of native data, beliefs, and products over the network. They may not have a token involved with the chain.

### 7.3 Consortium blockchains

Set of Organizations controls consortium blockchain. It combines the features of both public and private blockchains. Multiple parties will be part of the network. Not all users are permitted. This blockchains are quicker than public blockchains.

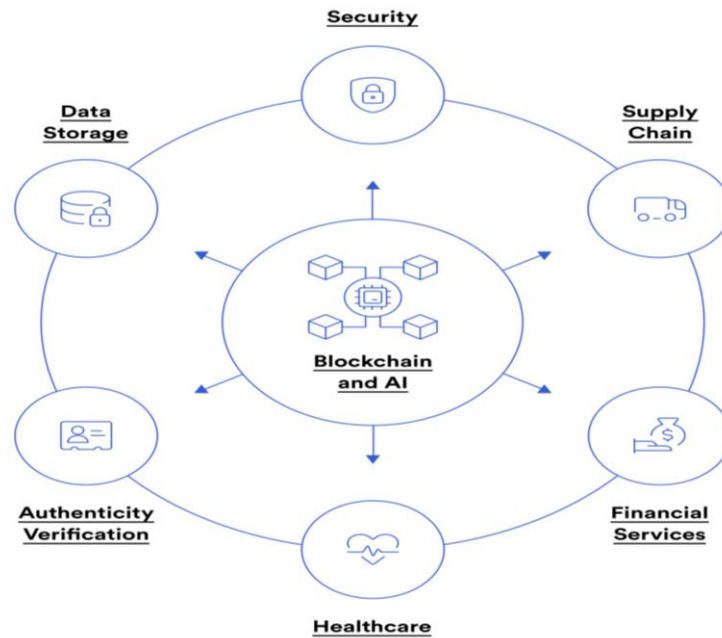
### 7.4 BaaS (Blockchain-as-a-Service)

BaaS enablement leads to new public-private collaborations and also supports the capture of new



business possibilities and company-customer interaction models. In order to construct smart contracts, developers are also given the ability to provision BaaS services with a single click.

## 8. AI and Blockchain Use Cases



**Fig 1: Use cases of AI and Blockchain**

### 8.1 Security

AI systems with its advantage in protection, restricts their ability to be controlled or used for malicious purposes can be implemented. Unlike centralized systems, which may be compromised by a single point of failure, decentralized infrastructure is dispersed among numerous nodes and various separate private keys, makes it more difficult for a single attacker to hack the whole system.

### 8.2 Supply chain

Combined AI and blockchain have changed supply chains across sectors and created new opportunities. This merged technologies may increase precision and reduce the effect of fraud by digitizing paper-based operations and allowing things to be tracked in real time from manufacturing to distribution.

### 8.3 Financial Services

More efficient and secure payment systems are employed in the financial services industry. AI can be used to detect fraudulent behavior and trends, while blockchain technology may be used to ensure the confidentiality of transactions and accuracy. Artificial intelligence combined with blockchain technology lower the expense and duration required for cross-border transactions, making the financial system more accessible.

Decentralized marketplaces are also being built using AI and blockchain. Buyers and sellers can trade directly without the use of intermediaries on decentralized marketplaces. AI may be used to enhance the marketplace and provide customised suggestions to buyers, while blockchain technology may assure the reliability and authenticity of commodities.

#### **8.4 Healthcare**

The proposed method employs a blockchain platform to determine the health state of patient diseases, insurance claim process, clinical and biomedical researches. It brings qualitative changes in the healthcare sector. AI and blockchain technology can improve the privacy and security of healthcare data by providing a model for health information exchanges and transferring records.

Immunization is an important method for avoiding infectious illnesses in today's society. The safety of vaccines is intrinsically related to healthcare. As a result, it is necessary to build an effective vaccination regulatory system. An Ethereum smart contract was used to query personal immunization information and vaccine supplies in the vaccination blockchain system.

#### **8.5 Authenticity Verification**

Cryptographic validation and time stamping could aid in the development of decentralized systems to manage data collection, verification, and distribution in a future where distinguishing between AI- and human-generated material is crucial for societal stability. Such systems could help content creators and users develop trust in the information they share.

#### **8.6. Data Mining**

Large-scale data analytics can be easily handled by significant advantages of blockchain technology. Data is stored in a secured and decentralized network which is one of the most successful long-standing methods to secure the information.

This large scale data helps the massive quantities of data created on-chain as blockchain technology progressively supports fundamental elements of human economic and social activities. As a consequence, these models may be able to identify broad patterns and give actionable knowledge through predictive analytics, allowing organizations and people to make educated decisions regarding the opportunities presented by the on-chain economy.

#### **8.7 Smart Contract Development**

Smart contract developers' productivity can be enhanced by magnitudes of user data. They are self-executing computer programs that permit the users to exchange money, assets or any significant value. Smart contract apps might be enhanced with AI-powered APIs that provide real-world sensor analytics. It exchanges transparent, tamper proof and conflict free without any middle man.

#### **8.8 Applications for Resource Management**

Integration of blockchain and artificial intelligence require network resources, its integration in resource management apps entails a variety of scenarios. Given that blockchain mining consumes significant computer and energy resources. An efficient bid strategy is based on deep learning for distributing edge computing resources

### **9. Cyber Security**

One of the most important applications of the two technologies is in cyber security. Cyber security risks are increasing at a rapid pace, and conventional protection measures are quickly becoming outdated in the face of new attack vectors. Artificial intelligence can identify and respond to assaults, while blockchain technology provides data security and integrity. By combining AI with blockchain, it is



feasible to build more safe and efficient cyber security solutions for people, organizations, and governments.

## **10. Application of AI and blockchain**

### **10.1 Intelligent Computing Power**

Running a blockchain on a portable device with all of its encrypted data demands a large amount of CPU power. Before executing a transaction, the hashing algorithms verify if each alternative fulfils the problem's statement.

### **10.2 The Smart Grid**

Smart grid, is a part of the energy Internet. They are becoming more oriented towards distributed energy trading. As a result, the distributed structure of smart blockchains can significantly aid in the transformation of smart grids from centralized to distributed electricity. The decentralized structure of smart grid blocks allow only trusted data flow between different parties.

### **10.3 Creating a Variety of Data Sets**

In contrast to computing-based projects, blockchain technology offers a public blockchain network that may be accessed by anybody, anywhere in the world. Creating a blockchain API of APIs would allow A.I. agents to communicate with one another. As a consequence, several algorithms based on different knowledge sets may be created.

### **10.4 Internet of Vehicles**

Internet of Vehicles (IoV) has grown in importance in the field of intelligent transportation. Implementing a smart blockchain that provides trust assurances, strong data protection, and efficient incentive mechanisms can hasten the advancement of Internet of Vehicle technology. Through blockchain technology, new participants (vehicles, people, and service providers) are added to the chain, which improves data information interchange, boosts the security of stored data, and is immutable due to its openness, anonymity, and immutability.

### **10.5 Data Security**

Through knowledge, AI learns about the global community and what is going on in it. AI collects all knowledge and data and as a consequence, it will develop itself. It provides security to the databases by allowing access to trusted users. Storing the data on a blockchain, which an AI can only access with permission and after following the proper procedures, might offer us major benefits such as personalized suggestions.

### **10.6 Data Protection**

AI depends and learns about the world from information fed to it and so it may advance indefinitely. In Blockchain, only encrypted data are stored that allows to read by those granted access. Healthcare data or financial information is too important and sensitive that to trust a single corporation and its algorithms. Storing this data on a blockchain, which an AI can access with permission and after following the necessary regulations, might offer us significant benefits such as customized recommendations.

### **10.7 Data Monetization**

Information validation is another breakthrough advance that might be performed by combining the two technologies.. AI algorithms learn and expand with AI networks by purchasing data directly from authors via data markets. This will make entire process more honest than it is now, with no manipulation. An information industry like this will also make AI accessible to almost all small and large businesses. AI development and feeding are too expensive for organizations that do not create their own data.

### **11. AI in Blockchain: Challenges and Considerations**

Instruction regarding the benefits, risks, and challenges associated with the convergence of AI and blockchain might help build public trust in their implementation and increase consumer interest for artificial intelligence (AI) systems that benefit from blockchain-based security mechanisms.

#### **11.1 Collaboration in Off-Chain and On-Chain Storage Data**

Both blockchain technologies and traditional data storage systems have advantages and limitations. Off-chain storage and computation infrastructure are required for both traditional information systems and blockchains to improve performance. In order to accomplish this, blockchain technology must be connected with current information systems, with the primary goal of ensuring the quality and information stored on the chain .Data held in traditional databases must be consistent. Statistics are also important for AI progress. There are still several challenges to widespread AI adoption, including data quality issues, data monopolization, and data misuse. These challenges are addressed by using block chain.

#### **11.2 Privacy and Security**

For blockchain applications, privacy, security, and landing protection are critical factors. Securing user privacy is important to blockchain applications to be widely accepted. Information hiding and mistaking identities are two common blockchain privacy protection tactics. Ring signatures and group signatures are two type of privacy-protecting signature methods to hide the identities of users in transaction. Supervisor can access data only with supervisor's private key and protects the user data with identity of the users. Increased calculating complexity, on the other hand, leads in a less valuable system, necessitating more work to enhance its utility in real-world scenarios. It is challenging to comprehend how to employ AI algorithms wisely in order to increase inefficient performance. Furthermore, in order to be employed in a distributed setting, the present AI system must be upgraded.

#### **11.3 The Fog Computing Model.**

Fog computing is a new computing paradigm that enables localized computation and store data near IoT devices. Fog nodes are typically used to compensate for the extended delays caused by cloud storage and computing systems. Fog nodes are like small-scale local clouds. In terms of artificial intelligence and blockchain, forthcoming log data must support the use of machine learning and AI, as well as a blockchain interface via which fog nodes may manage, access, and administer specific data.

#### **11.4 Quantum computation.**

It is believed that future quantum computers would be capable of cracking public key encryption

and determining private keys. The present blockchain is built on digital signatures encrypted with a public key. This necessitates extensive research towards quantum-safe and secure blockchains capable of withstanding such breakability while maintaining high performance and scalability.

## 12. The Future of AI and Blockchain

The potential for combining AI and blockchains to transform multiple industries is immense. AI models are used throughout to proliferate various parts of the economy as organizations to automate operations, enhance efficiency, and expand their commercial offerings by embedding AI into a large portion of software products. Customers are increasingly turning to applications that are backed up by cryptographic guarantees. The integration of two technologies has potential to significantly affect the functioning of our society and economies.

- In the future, smart blockchain transaction and data storage modes may evolve into a hybrid architecture combining both on-chain and off-chain storage. On-chain storage provides the benefits of higher efficiency, cheaper costs, and greater privacy, whereas off-chain data struggles to gain from blockchain trust. Future study will concentrate on tightly integrating on-chain and off-chain data in order to match credibility on the chain to off-chain data.
- The majority of the block chain's technological problems focuses around issues of performance, such as process performance, confirmation of transactions time, and block capacity. To address the block chain's performance concerns, many solutions like according to acyclic networks, sharing of transaction routes, etc have been proposed; however, these solutions will unavoidably damage the block chain's credibility and security.
- Because of its consensus method and immutability, blockchain technology inherently ensures the validity and dependability of data, which can improve confidence in an open network. In the blockchain context, this involves the formation of distributed trust. Authenticating the identities of other nodes in the absence of a central authority will be an essential future study topic.
- It is important to increase public awareness about blockchain technology.

## 13. Conclusions

There is no denying the growing popularity of blockchain and AI-based technologies. In terms of data management with decentralized technology and AI design, a full evaluation of applications for intelligent systems is offered. Aspects of artificial intelligence for blockchain applications are also summarized. While both paradigms provide something unique, the degree of uniqueness and complexity differs greatly. Because digital currency is so prevalent in today's culture, blockchain technology enables the safe and distributed transfer of sensitive data, information, and transaction records. Two technologies, blockchains and artificial intelligence (AI) have received a lot of interest recently. This session explored the recent state of blockchain and AI collaboration, their applications, and the potentially innovative consequences of their distinct qualities. The majority of this research focuses on integration use cases such supply chains, financial services, healthcare, life sciences, smart grids, agriculture, and so on. According to our evaluation of the literature, the acceptance of blockchain for AI applications is still in the beginning stages, with many research challenges to be discussed. To address the block chain's performance concerns, many solutions like according to acyclic networks, sharing of transaction routes, etc have been proposed. And also concentrate on tightly integrating on-chain and off-chain data in order to match credibility on the chain to off-chain data.

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